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DEVELOPING AN EFFECTIVE ROAD SAFETY STRATEGY

by

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ORIGINS

The January 1994 issue of the REAAA Journal contained a copy of the Keynote Address to the 1993 Conference on Asian Road Safety. Given by Dr. Ian Johnston, Chairman of REAAA's Technical Committee, the Address considered the usefulness to Asia of the road safety experience of motorised countries. This paper develops several of the concepts in that paper in order to go on and propose a framework for a road safety strategy which allows for the varying needs of countries in the Asian region. The paper was presented at the Asian Roads and Highways Summit held in Hong Kong in late 1994.

INTRODUCTION

Too often, strategic planning is considered to be some mystical process which enables the future to be clearly foreseen and plans developed to meet that future. These plans are often seen as an end to the process, rather than a beginning, and after a conspicuous launch they can find their way onto inconspicuous shelves where they serve out their not-too-useful lives.

The value of true, living, strategic plans is that they describe the current situation, propose a range of possible future scenarios and then develop a series of contingency plans to deal with those scenarios in the light of actual developments.

Thus, although a plan may be developed and issued to be acted upon, the strategic planning process must be a continuing one with strategic directions changing as the unfolding environment dictates.

The process is therefore one of managing change and, as many recent events around the world have shown, this change process can often occur very rapidly. The extensive mobility afforded by a highway transport system is a central mechanism by which countries pursue their economic and social goals. A rapid change in levels of motorisation is already well underway in the South East Asian region and is also seen amongst many of the world's developing countries. Although the exceedingly high growth rates of the region have slowed somewhat, the changes in motorisation are still occurring at a far higher rate than in developed countries. These changes place considerable strain on the various institutions responsible for transport systems, and often exhibit themselves in terms of the high casualty rates as found in many South East Asian countries. The dynamic nature of this change makes it important to set any discussion of a road safety strategy within the context of the road safety system within which it must apply.

Given the differences in road and traffic system development in various Asian countries, a simple hierarchical model of the typical road safety system will be used as a basis for describing the essential issues which must be addressed by a road safety strategy. The stage of development of any given country's road and traffic system could then be used to determine the level in the hierarchy on which it is most appropriate to centre attention.

The paper attempts to provide a basic framework through which it is possible to develop a road safety strategy which, to some extent at least, also allows for differing needs generated by different maturities of road system. In this way the plan can be developed to directly meet the needs of those generating it. This is a most important point. Despite the growing interest in, and experience of, the Asian region in recent years at the Australian Road Research Board, it would be inappropriate for anyone from such an organisation to offer solutions to Asian countries, the solutions must be their own.

There are, however, many safety measures which have been developed in western motorised countries that can and indeed are being transferred to Asian nations. There are many aspects of road design, construction and maintenance, traffic management tools and techniques, legislation and regulation, even vehicle design and some programs directed at behaviour change, that can be applied with appropriate adaptation to suit local cultural differences. However, it is also true that some of the major safety problems characteristic of Asian nations, and the environment in which they must be addressed, have never been experienced in the western motorised world. These

problems will require innovative solutions that are best developed in the countries concerned by those facing the problems.

THE CONTEXT OF SAFETY WITHIN THE ROAD SYSTEM

Many communities and governments are becoming increasingly aware of the significance of road safety in a broader range of contexts such as overall transport, health, and occupational health and safety.

The effects of changes in urban planning and industrial activity, in working practices and demographic patterns, are having a considerable impact on the various modes of transport, and hence road safety, as development continues. The role of transport as a work environment has the potential to make road safety a greater priority in occupational health and safety, and with road trauma a major cause of the loss of productive lives, the impact on hospital systems is sure to put road safety on the agenda of health professionals.

This increasing awareness of road safety stands beside a growing concern over energy consumption and the environmental effects of road traffic. Energy and environmental issues are impacting on an ever increasing number of countries, particularly those experiencing high rates of increasing motorisation. The debate is one of transport provision and mobility, community needs, and individual freedoms.

Unless improvements to the overall system are made, the consequences of this growth will include:

* greater congestion and reduced urban and rural mobility,
* more serious air pollution problems in cities,
* reduction in quality of life, especially in urban areas,
* greater economic loss from traffic delays, accidents and environmental impact, as well as
* increases in accidents and trauma.

Any increasing concern for the environmental, economic, social and recreational impacts of transportation management as well as those of safety, confront the need for greater economic rationality of not only transport management but public accountability and micro-economic reform.

Government concerns for road safety will increase not just because of increasing trauma, but because of a growing realisation of the true economic cost of accidents and casualties and an awareness that projections of increasing growth in population and traffic will further exacerbate the current problems.

This placing of safety within an overall context is important since if road safety programs are to be effective they need to be conceived within, and fundamental to, the context of the coordinated management of mobility and transport. Safety can be regarded as a quality of the system, for which a proper economic valuation is needed in the context of developing and assessing other strategies to manage the system. The relative potential for road safety initiatives to return benefits, in both financial savings and human terms, must be established and demonstrated to enable appropriate resources to be allocated against the requirements of other aspects of system management.

It is therefore important that road safety strategies be formulated in parallel with other strategies for network development, and acknowledge the sometimes competing objectives of safety, amenity and mobility. There is clearly a potential for broader synergistic effects – in terms of road safety benefits – through concurrent development of strategies from safety, mobility and environmental standpoints.

THE ROAD SAFETY SYSTEM AS A STRATEGY FRAMEWORK

The framework of a road safety system is proposed as the basis for the development of an appropriate road safety strategy. Figure 1 shows a 3-tier hierarchical road safety system which comprises: the vision, which drives the system; the processes, which enable the system to operate; and the tools, developed and used to meet the needs identified and addressed by the system.

This overall model represents a mature road safety system, but its hierarchical nature allows strategies to be developed for safety systems of various levels of maturity, often related to a given level of motorisation and/or economic development.

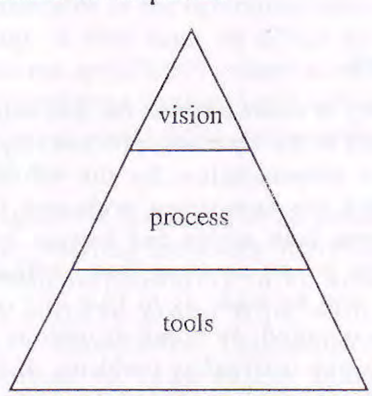

Fig. 1 Road safety system

Thus, for a relatively immature safety system, a strategy might be framed primarily around the vision for, and commitment to, the system. Commitment to the required processes might be sought by establishing the cost of accidents and their relationship to other possible economic reforms. Alternatively, national and

international safety comparisons might be made, and meaningful and appropriate safety targets generated to highlight the problems being faced.

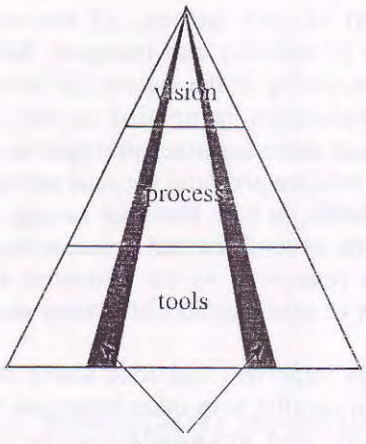

Fig. 2 Provision for initiatives

At whatever level the model is considered to be operating it will, of course, be necessary to develop and use appropriate tools to address immediate problems. The usefulness of the proposed model is that such initiatives can, wherever possible, be seen and developed as 'vertical slices' of the model, linking with the appropriate processes (Fig. 2).

This helps to ensure that tools are not developed in isolation but remain within the overall system framework and are ultimately consistent with the road safety strategy developed.

The elements of a road safety system which should form part of a road safety strategy – and these are particularly in the areas of vision and processes, not merely a catalogue of tools – will now be outlined.

VISION

Commitment

It is necessary to create a vision for road safety through a commitment to the necessary processes by those with the ultimate responsibility for the whole transport system. With the competing pressures for limited resources from both within and outside the transport system, this is not an easy task. Although some suggestions will be made as to how this commitment may be encouraged, in some situations it may be necessary to wait until safety problems, and associated external pressures, increase to a point where governments themselves begin to invest – both financially and administratively – in improving road safety.

In Australia, for example, it was not until the early 1970's that Federal and State governments began to systematically 'invest' in major road safety programs.

Relationship to economic reform

In many countries transport forms a large part of the micro-economic reform agenda. In terms of limited resources, and the prevalence of economic rationalism in much of current decision making, the economic reform argument associated with potential savings from road safety should carry weight. There is an investment to be made in road safety which has returns in the form of reduced accident costs. In Australia recently, in a year when total health expenditure was $26 billion and the balance of payments deficit was $16 billion it was estimated that, when successful, the tortuous waterfront reform package would save in the order of $1 billion per year. In that same year road accidents were estimated to have cost Australia $8 billion.

Unfortunately, robust figures such as these are not always available and, even when they are, any initial expenditure required to produce even quite substantial potential benefits can often be a major problem.

A road safety 'champion'

Obtaining the support of a powerful lobby group or identifying a high profile 'champion', who will keep road safety on the transport agenda, can be of great assistance in both the development and promotion of a road safety strategy.

Targets

There are a number of different ways of measuring the safety of a road system. For some, particularly those responsible for the system's upkeep, casualties per unit driven (usually veh-km) is seen as an appropriate measure, since it relates safety performance to level of use. Since reliable measures of vehicle use are generally difficult to obtain, the number of registered vehicles is often used as a surrogate for road use.

An alternative measure of safety is in terms of the number of people at risk, often expressed as deaths per 100,000 population. Of these two measures of overall system safety, whilst both have their weaknesses, that based on population has the advantage of allowing direct comparisons between road crashes and other causes of death in a country. Thus those responsible for public health problems can assess the contribution made by the various causes when making decisions on how best to allocate available resources.

Such measures can be used to raise awareness of problems and as a basis for safety targets. It is, however, unwise to use such measures for direct comparisons between the safety performance of one country and another without great care. Whether the comparison is between Asian countries themselves, or with countries such as the USA and Australia, the danger is that the comparison is likely to be between two very different transport systems.

But such international comparisons of safety do help to scope realistic targets to aim for. There is always much to learn from the experience of others, particularly if the comparisons made are as valid as possible. This means that, even between countries in the Asian region, targets should be developed from the experience of countries with similar levels of motorisation, vehicle fleet and land use patterns. This will ensure they address similar types of safety problems.

The most effective targets, however, will not be general ones but those that relate to the particular problems faced. To be most useful, targets should also be as specific as possible. Whether those targets be related to reductions in pedestrian, motorcycle or bus occupant accidents, they are far more likely to be of value than targets expressed as unspecific national reductions in casualties per head of population.

The use of specific, problem-based targets also has the capacity to bring accountability to those agencies responsible for the remedial measures required to address the targeted problems. This area of institutional responsibility and the coordination of activities required, is a major component of the 'process' associated with road safety systems which is considered in the next section.

PROCESSES

Once a commitment has been generated for road safety, there are a number of processes that will facilitate the move from commitment to the measures which will actually improve the levels of safety.

Organisational structures and their coordination

Many road safety problems throughout the world have, in the past, been aimed at different aspects of the road safety problem, with the result that improvements have often been fragmentary. This is understandable since road safety involves a wide range of diverse organisations. Each has its own particular area of expertise, often associated with the ability to act only within a given set of parameters. This reinforces an individual organisational approach to problems. Any continuing lack of funding and other resources for road safety often makes it necessary for organisations to protect their own funds and resources. All these organisational factors mitigate against the development of coordinated road safety programs.

Many management practices also make it difficult for organisations to combine successfully for joint programs. Apparently independent functions such as road building, traffic management, law enforcement, health care and education are usually assigned to unrelated government departments. Managers are rewarded for efficient and effective management of departmentally oriented programs rather than contributions they may make towards the attainment of goals jointly with other departments. Reward is certainly less likely to be forthcoming for a reduction in departmental activity in favour of support for other more effective programs which might better be managed within other departments.

Taking into account the wide range of factors involved in the causes of accidents, it is important that all available expertise should be brought to bear on the problem. Ideally this would point to a horizontally structured, multi-disciplinary organisation dealing with the management of all aspects of road safety. Unfortunately the reality is that the structures of most organisations involved are usually vertical and often strongly related to a single profession. This can often lead to biased perceptions of both the problems and associated solutions. It is important therefore to consider how an effectively coordinated road safety program can be developed.

There are a number of organisational strategies that can be considered in order to achieve a coordinated road safety program:

High profile ministry

The responsibility for overall road safety planning can be placed within a high profile ministry, such as a Premier's or Prime Minister's Department. The status of the office results in road safety taking a higher priority and profile. The responsibilities for planning, prioritising and coordination are separated from the actual delivery of road safety countermeasures which encourages a better balanced overall program. The responsible office can be made accountable for the success of the total program although not for any one segment within it. The managers of individual programs are responsible for the success of their own programs and accountable to the centralised office. An added advantage is that such an office can influence programs not specifically related to road safety, but which nevertheless impinge upon safety, such as the installation of power poles, public transport policy, planning, etc.

Such a system is not suited to all jurisdictions, and it is not practical for every individual issue of government responsibility to be addressed by a special purpose group from within a Prime Minister's Department. There must be a strong commitment to road safety leadership and coordination already generated at high level before attempting to adopt such an approach and the officers charged with responsibility must be of the highest calibre.

Although not an approach widely adopted, it is interesting to note that in Japan responsibility for road safety planning is within the Prime Minister's Office. Supported by considerable levels of

funding, the Japanese reduced their fatality rate, albeit from a very high level, by nearly 70% over a 10 year period.

Responsible agency

Another approach to road safety coordination is to designate a department or agency responsible for the overall program. A close association between overall planning and much of the implementation can develop increased continuity for much of the program. However, whichever department is chosen, and there will usually be many claimants, that department will almost inevitably tend to bias towards its own programs. For a variety of reasons it will not always be possible to guarantee the full cooperation of other departments, each of which may have their own safety objectives and could often be competing for the same funds. In such circumstances it is difficult for one department to exercise control over another. This lack of control also weakens the responsible department's capability to effectively integrate diverse programs. Conversely, that department cannot be held accountable for the overall success of an integrated program if that department cannot hold others accountable.

Ad-hoc group

A third approach is to establish a widely representative ad-hoc group to identify areas of work and to develop a general plan of action for approval by government and action by various organisations active in the road safety area both inside and outside government. If created at a sufficiently high level, such groups or committees have many of the advantages of more formal groups established within high profile departments. Their wide representation allows them to cut across departmental and other parochial boundaries and respond to identified needs from whatever sources. This type of committee is usually appointed, and hopefully supported, by a senior politician – a form of 'champion' – and through them the deliberations of the committee can be made public, increasing the likelihood of recommendations being implemented.

Whilst very valuable for creating early initiatives and raising the level of awareness of road safety needs, the special committee approach has a number of weaknesses as an on-going means of implementing and controlling a comprehensive road safety program in the longer term. It is often difficult to maintain the initial enthusiasm of co-opted members in such groups. Being representative in nature there can be membership changes which affect the continuity of the group's approach. Most importantly, however, such groups can usually only recommend action, they have no control over funds. They are not actually accountable for the success of the proposed program, how can they be when they have no direct access to the resources necessary for the implementation and evaluation of their recommendations.

It is very difficult to suggest a preferable structure for ensuring coordination and cooperation in the road safety area, much will depend on the environment into which it is to be introduced. It is possible, however, to suggest that any strategy proposing such a structure should consider the major requirements as ideally having:

* a high profile,
* access to a 'champion',
* wide representation and influence,
* responsibility for planning and prioritising separated from delivery,
* commitment to cooperation at both policy and operational levels,
* dequate monitoring and feedback processes,
* management acceptance of wider safety goals,
* adequate independent funding, and
* operational expenditure on priority rather than functional basis

Funding

An important part of any road safety strategy is to address the question of funding. Whilst the use of transport regulations are often seen as an 'easy', low-cost option through which to address road safety, a comprehensive, balanced road safety program requires a range of actions which will inevitably need significant funding.

As already indicated, a major source of road safety funding is likely to be individual departmental budgets. Specific allocations from appropriate agencies might also be made for road safety – a recent Prime Ministerial initiative in Australia injected $100 million into safety based road improvements, while specific charges on petrol in at least one Australian State have been directly hypothecated for the improvement of the road system, which will improve the safety of its operation.

It might also be possible to generate either direct funding or in-kind support from organisations in the private sector. Organisations such as motoring bodies and various sections of the media can often assist, particularly in the publicity and education areas. Organisations such as the World and Asian Development Banks will sometimes provide loans for the support of road safety initiatives. However,

proposals must be well argued to compete with road construction projects etc. for the limited funds available.

Finally, a recent and novel method of funding road safety has been developed through the use of third party insurance premiums. This has been tried in several countries and in at least two Australian States. In the State of Victoria the government-owned third-party insurance office allocated a percentage of its premiums to two areas of accident prevention. The first was the perhaps traditional support given to broadly based media and information campaigns. However, the campaigns were targeted at two high priority safety issues in the State: speeding and drink driving. These two issues also provided the focus for the second, more novel form of support provided. The insurance office sponsored the purchase of police infrastructure in the form of mobile random breath testing stations – 'booze buses' – and over 60 automatic speed measuring cameras. The funding for this equipment would not have been available in the normal police budget.

Assessment of the effect of this integration of enforcement and public education has shown it to be remarkably effective. Indeed, the insurance office involved has subsequently made savings associated with the initiative which have been greater than the costs incurred.

The process is, of course, not only a good example of innovative funding for road safety, but illustrates further both the synergy to be gained by the coordination of activities across organisations, and the important role funding can play in unlocking the process.

Training and Technology Transfer

As has already been discussed, road safety experience from developed countries cannot, for the most part, be transferred directly to motorising countries. Indeed many of the problems being experienced in Asia have never had to be addressed by western-type road systems during their development. It is therefore necessary to develop a cadre of professionals experienced in road safety practices per se, and in the specific needs of their own countries in particular.

This can be achieved through the development of professional self sufficiency where training develops specific skills leading to a sense of ownership of problems and commitment to their solution. This can then be applied to the management of safety within both the national and local road systems.

A regional technology transfer network can also be created that is both structured, to ensure continuity, and operates on a more informal colleague to colleague basis creating a network for ongoing information and technology transfer in the road safety area. This will ensure that the benefits continue to accumulate in the longer term as on-going training of successive levels of professionals and operatives become locally driven. It is important that even if initial training has to be lead by international experts using local support, a group of well informed road safety officials is created in countries of the region. With such a 'train the trainer' approach, which directly addresses local problems and solutions, continuing road safety technology transfer and the wider development of skills can be fostered.

Data

Accident data provides the link between the processes and tools of a road safety system. On the one hand appropriate data systems ensure that the right data is available. This data then becomes a required adjunct to many of the tools used to address the problems identified.

A key element of a successful road safety system is the ability to analyse the current situation, identify problems and propose a range of measures to address those problems. Clearly data is essential for both identification of problems and for monitoring the effects of remedial actions. The importance of establishing and maintaining accident data systems for these purposes cannot be over-emphasised.

It is not necessary for the systems developed to be elaborate or costly. Certainly it would be unwise to simply import complex data systems used with highly developed road networks. Unless adequate support can be readily provided, the cost of over-detailed data collection and storage can become prohibitive. Another paper at this conference describes a straight forward system developed specifically for use in motorising countries. Such a system could certainly support major improvements in road safety system information.

This may well be a continuing process. In Australia efforts are still being made to secure greater uniformity and reliability of data obtained from accident reporting. Agencies there are turning to innovations such as hand held computers to simplify the collection task and subsequent data handling, such is the importance placed on good data.

TOOLS

The tools of a road safety system are the direct measures that can be introduced to impact the levels of safety being experienced in the system. Such measures may vary from remedial treatments at hazardous road locations to enforcement regimes or public awareness campaigns.

Traffic accidents are complex occurrences and often the solutions can be just as complex or difficult to establish. There is a need to understand in detail the

nature of the safety problems being faced. For Asian nations it has already been noted that many of the problems will be unique. It is very likely that, given adequate skills and experience, the best solutions will be those generated by local road safety workers. It is local knowledge that will enable judgments to be made as to whether proposed solutions will be acceptable, and successful, within the local social, cultural and educational context.

Certainly, as mentioned earlier, extreme caution is needed when attempting to transfer safety measures from one traffic system to another. In particular beware of experts from western motorised countries bearing gifts of easy, proven solutions. Of course there are many measures that can be transferred or adapted for use between appropriate traffic environments. Strategies should be developed based on a careful selection of these, complimented by locally developed or validated solutions which will so often be needed to address local problems.

SUMMARY

The paper has attempted to provide a basic framework through which it is possible to develop a road safety strategy which, to some extent at least, allows for differing needs generated by different maturities of road system. In this way a plan can be developed to directly meet the needs of those generating it.

A 3 tier hierarchical road safety system is proposed which comprises: the vision, which drives the system; the processes, which enable the system to operate; and the tools, developed and used to meet the needs identified and addressed by the system.

A vision for road safety can be created through a commitment to the necessary processes by those with the ultimate responsibility for the whole transport system. Obtaining the support of a powerful lobby group or identifying a high profile 'champion', who will keep road safety on the transport agenda, can be of great assistance in the creation of a vision and both the development and promotion of a road safety strategy.

International comparisons and safety targets can raise awareness of safety problems. However, targets should be developed from the experience of countries with similar levels of motorisation, vehicle fleet and land use patterns. This will ensure they address similar types of safety problems. The most effective targets, however, will not be general ones but those that relate to the particular problems faced and to be most useful should also be as specific as possible.

Once a commitment has been generated for road safety, there are a number of processes that will facilitate the move from commitment to the measures which will actually improve the levels of safety.

Many organisational structures mitigate against the development of coordinated road safety programs. A number of organisational structures are proposed that could facilitate a coordinated road safety program: a high profile ministry, a responsible agency and a senior ad hoc group. It is difficult to suggest a preferable structure for ensuring coordination and cooperation in the road safety area, much will depend on the environment into which it is to be introduced. The paper does, however, suggest the major requirements such an organisation should ideally have.

An important part of any road safety strategy is to address the question of funding. A comprehensive, balanced road safety program requires a range of actions which inevitably need significant financial support. A number of alternative sources that might be strategically targeted are identified.

Road safety experience from developed countries cannot, for the most part, be transferred directly to motorising countries. Indeed many of the problems being experienced in Asia have never had to be addressed by western-type road systems during their development. It is therefore suggested that a cadre of professionals be fostered which might become experienced in road safety practices per se, and in the specific needs of their own countries in particular. This could be achieved through the development of professional self sufficiency where training develops specific skills leading to a sense of ownership of problems and commitment to their solution.

It is suggested that accident data provides the link between the processes and tools of a road safety system. Data is essential for both identification of problems and for monitoring the effects of remedial actions. It is felt that the importance of establishing and maintaining appropriate accident data systems for these purposes cannot be over-emphasised.

The tools of a road safety system are seen as the direct measures that can be introduced to impact the levels of safety being experienced in the system. Extreme caution is suggested when attempting to transfer safety measures from one traffic system to another. It is acknowledged that there are many measures that can be transferred or adapted for use between appropriate traffic environments. Strategies should be developed based on a careful selection of these, complemented by locally developed or validated solutions which will be needed to address local problems.

If an attempt is made to develop a road safety strategy using the framework provided here the developers should not despair if complete success is not immediately forthcoming. One of the major strategic targets for improved road safety has been identified in

the paper as the coordination of responsibility and availability of funding across relevant organisations. It has taken many countries, well down the path to fully developed road and transport systems, many years to come to terms with this fact. It has been one of the more costly lesson to learn. Perhaps nations not so far down the same path can learn quickly from those that have gone before them.

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MAINTENANCE BY CONTRACT IN THE PHILIPPINES: EXPERIENCE GAINED DURING FOUR YEARS OF PROGRESSIVE PRIVATISATION OF ROAD MAINTENANCE ACTIVITIES

by

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BACKGROUND

The privatisation of maintenance operations of the Department of Public Works and Highway (DPWH) was initiated in 1987 under an ADB Technical Assistance Grant to the Philippine Government. Under the grant two pilot areas were identified:

* Batangas Province, 100 km. south of Manila, and
* Bohol Province, off the coast of Cebu Island

The objective of the pilot project was to establish maintenance by contract in the pilot areas and to compare the efficiency and costs against the traditional mode of maintenance by Force Account utilising the resources of the DPWH.

In the two pilot provinces, 50% of the road network was selected for maintenance by contract. Selected roads represented a complete range of road conditions ranging from very good to poor.

Suitable work items were identified and specifications, work programmes and estimates were prepared for unit rates contracts. By mid 1988 the first projects were bided.

In 1989 the implementation of maintenance by contract continued in the pilot areas. Following the good results, the DPWH formulated a nationwide implementation plan by mid 1989.

The objective of the nationwide plan was for gradual implementation of maintenance by contract over a five year period, as follows:

YEAR	1990	1991	1992	1993	1994
By Contract	40%	51%	61%	72%	84%
Routine Maintenance	9%	19%	28%	38%	48%
Periodic Maintenance	31%	32%	33%	34%	36%
By Force Account	60%	49%	39%	28%	16%

Experience gained during the pilot project showed that maintenance contracts consisting only of Routine Maintenance are less attractive to the contracting industry. Moreover, maintenance has been traditionally implemented in the proportion 60% Routine and 40% Periodic. This has led to a typical packaging of combined Routine and Periodic maintenance activities, covering a length of about 20-50 km.

Reviewing the 1990, 1991 and 1992 implementation programmes, the effects of the 1990 Luzon earthquake and the 1991 Mt. Pinatubo eruption and the experience gained in other countries, it was found advisable to scale back the target implementation in order for the Government to maintain some resources in case of disaster situations. The maximum degree of privatisation was drawn back to 70%, enabling the Government to maintain some basic work crews and equipment to continue maintenance by force account and to be drawn upon for the initial response to natural calamities. The revised implementation plan is as follows:

YEAR	1990	1991	1992	1993	1994
By Contract	40%	51%	61%	65%	70%
By Force Account	60%	49%	39%	35%	30%

The following questions were asked prior to the start of the nationwide implementation in 1989–1990:

* How can the reduction of the DPWH work force be achieved?
* Is the contracting industry ready for maintenance by contract?
* Is the DPWH able to handle the contracting of the maintenance activities?

REDUCTION OF DPWH WORK FORCE

A survey of the DPWH work force was conducted in 1989 which yielded findings similar to a survey conducted on a smaller scale during the pilot project. The 1989 work force consisted of 12,300 labourers, operators and drivers. Of the 12,300, two-thirds were daily (casual) workers while one-third were permanent employees. 80% of the permanent employees were at the age of 45 years or more, of which there was an annual rate of retirement of about 3%. For the daily work force the majority were between 30-40 years of age.

In late 1989, a projection of the needed work force was prepared, as follows:

YEAR	1989	1990	1991	1992	1993	1994
Needed Work force	8,500	7,500	6,400	5,500	5,200	4,900

Comparing the needed work force of 8,500 to the existing work force of 12,300 it was necessary to reduce the work force. To reduce the work force, the Government introduced a "no new hiring" policy where vacant positions would not be filled. To further address the overstaffing, directives were issued requesting the implementing offices to adhere strictly to the number of work force as per their force account maintenance program, laying off a considerable number of the daily work force.

To absorb the staff layoff, during prebid and preconstruction conferences the contracting industry was encouraged to hire the laid off staff.

The social aspect of the very drastic reduction, especially during 1989, was cushioned by the fact that those laid-off belonged to the younger (and more industrious) age groups of the daily work force and the considerable number of laid-off personnel actually being absorbed by the contracting industry.

The long term goal to reduce the work force to about 5,000 has been met, as the actual work force has been reduced as follows:

YEAR	1989	1990	1991	1992	1993	1994
Planned	8,500	7,500	6,400	5,500	5,200	4,900
Actual	12,500	7,600	5,900	4,700	5,000	–

READINESS OF THE CONTRACTING INDUSTRY

The maintenance projects being fairly small projects with a size ranging from 1 to 1.5 million pesos (US$40,000–55,000), are meant for locally based small to medium sized contractors, for various reasons:

* The contractors are based near the work site, thus mobilisation time and cost are minimal
* The contractors are well known to the implementors ensuring that only capable contractors are prequalified.
* The local contractor's effort will be seen for the good of the community.

During the initial years (1990-1991) meetings were held with the construction industry to draw attention towards the maintenance projects. Contractors were informed about the nature of the projects, highlighting especially the fact that the contractor's work is a continuous effort over the contract period (normally one year) against the usual perception that projects should be completed as soon as possible. To make the contractor understand that he had to work under a schedule provided by the Government instead of their own work program took some time and efforts.

In the early stages, only a few contractors were interested in the maintenance projects and few had sufficient experience and equipment. Now the contracting industry has grown with the maintenance projects, investing in new equipment. Some have even specialised in maintenance only. During the later years, a true competitive environment has evolved.

HANDLING OF MAINTENANCE PROJECTS

Maintenance by contract is also new for the DPWH. For construction projects, contractors are given a relatively free hand in implementing their projects while for maintenance contracts considerable interaction is required and supervision needs to be tighter. For example, when a pothole has to be patched, quantities cannot be assessed beforehand and it has to be done during the progress of the work.

Considerable information dissemination and training effort were undertaken prior to the start of the nationwide implementation of the maintenance by contract scheme. A manual was prepared covering

all the steps from project identification to the implementation.

In order for the idea to be sold to the managerial level of the DPWH, conferences were held for Regional Directors, District Engineers and City Engineers. Simultaneously, training courses were held for the implementors of the program, mainly Maintenance and Area Engineers of DPWH and their assistants, where every step of the process was covered through lessons and workshop exercises, from the planning, preparation, bid, award to the implementation. During the first year the meetings were mainly presentations while in succeeding years they were more on dialogues where experience gained was discussed and subsequently became the basis for improving the system.

The engineers of the DPWH have developed with the challenge and at present the Department has a staff of full-fledged Contract Maintenance Managers.

By and large the 1990 to 1994 implementation of maintenance by contract can be considered successful. The implementation has increased following the targets established in 1989 and revised in 1992 and so far, no major drawbacks have been experienced. The figures from 1990 to 1994 are as follows:

YEAR	1990	1991	1992	1993	1994
No. of Projects	247	351	412	626	appr. 700
Amount	160M	310M	518M	605M	1002M
Total Percentage (%)	16.5	33.3	39.4	49.0	56.0
Target*	15%	32%	47%	56%	57%

* *Combined Periodic and Routine Maintenance Projects*

The approximately 7% lacking in 1992 and 1993 were mainly due to the exception of the majority of projects in the region directly affected by the eruption of Mt. Pinatubo, in order to free resources to deal with the mud flows (lahar) during the rainy season.

MAINTENANCE BY CONTRACT VS. FORCE ACCOUNT

Comparison of maintenance by contract against by force account is not only a matter of comparing costs but also a matter of balancing advantages and disadvantages of the two systems.

The biggest advantage of maintenance by contract is the ability to control cost. If the project is to be bided the implementor knows the quantities to be completed throughout the year and can budget and plan the maintenance activities ahead, while by force account the implementor deals with a number of unknown factors such as unproductive time breakdown, adverse climatic condition and logistic problems.

Comparing contract maintenance to force account is also a matter of how efficient the force account organisation is. A review of the performance was made covering 1990, where 60% of the budget was utilised by force account, showed fairly poor results. Comparing the assumed performance (as per the Force Account Maintenance Manual) with the actual performance of each work crew showed that in two-thirds of the country's 15 regions, the work crews could not meet the performance standards. With work force being paid on a time basis, cost per unit accomplishment was higher. For contract maintenance with unit rate contracts, the cost of accomplishment is fixed after the project has been bided.

The Force Account Guidelines (Philippines Highway Maintenance Management System of PHMMS) are very flexible, especially in terms of quality of materials. It is often seen that substandard materials are being used in the absence of good but more costly materials, producing results of only a very short service life. In maintenance by contract, it is a contractual obligation to provide and place materials in accordance with specifications, consequently ensuring that the level of quality is maintained.

In maintenance by contract, where execution and supervision are separate, the right working environment is present ensuring that good quality work is accomplished. Further, the bidding process ensures that the work is done to the most advantageous price for the Government.

A price comparison between maintenance by contract and by force account was attempted in 1991 to cover the 1990 implementation. However, comparison was very complex as funding of maintenance by force account was done not only through regular maintenance funding by also through subsidy to equipment operation, hence resulting in unrealistic low rental rates on equipment used for force account maintenance. Furthermore, taxation of contractors is much higher for maintenance by contract than by force account, where tax is paid only on the materials acquired.

However, considering the above, the previously mentioned fairly poor performance of the force account organisation and using the average rates of a number of projects nationwide, maintenance by contract came out to be less costly than maintenance by force account, as seen in the table below for the most common maintenance activities.

ACTIVITY	FORCE ACCOUNT	BY CONTRACT
Manual Patching of Gravel Roads	100	88
Regravelling	100	64
Grading of Gravel Roads	100	81
Patching Bituminous Roads	100	78
Crack Sealing	100	91
Ditch Cleaning	100	82
Culvert Cleaning	100	55
Vegetation Control	100	51

(Expressed in relative figures)
Overhead cost assumed to be similar for both modes

WHERE TO FROM HERE?

So far it appears that privatisation of maintenance activities has been successful and smooth, and is basically the correct approach. However, there are still a number of concerns which need to be addressed to make the success story even better.

* The work force for force account
* The Government's holding of equipment
* Training of the contracting industry

WORK FORCE FOR FORCE ACCOUNT

Despite the fairly smooth reduction of the work force, there still remains a work force composed mainly of permanent employees, belonging to the higher age group. It can hardly be expected that a top performance can be achieved considering the working environment of being exposed to the climate and undertaking hard physical manual work. An early retirement program should be initiated in order to replenish the work force with younger personnel to undertake the remaining 30% of the work that will be done by force account, and to act during calamities. By offering attractive retirement possibilities the average age can be lowered for the force account organisation and subsequently a more efficient operation can be expected.

EQUIPMENT

With maintenance by contract, it was feared that a considerable number of the Government's equipment would be idle. However, with only about 42% of the equipment operational in 1989 idle equipment should not cause much concern (at least with respect to maintenance contracting). However, what should be of concern is the organisation holding and maintaining the equipment. This organisation needs to be reviewed and scaled down to a suitable size to keep the operational equipment going.

Privatisation may not be the answer for equipment operation, but changing the government's equipment centers into cost centers may be considered, where rental income can carry maintenance costs of the equipment. Requirements on rental of Government equipment to private contractors can be relaxed and equipment users given a free hand in terms of where to rent.

TRAINING THE CONSTRUCTION INDUSTRY

Despite the efforts to improve the performance of the construction industry through seminars and information meetings, there is still room for more improvement. The maintenance of the road network has not always been executed fast enough, due to poor site management. In visiting the work sites, equipment is often seen idle and the work force not properly instructed. The safety aspects for both the road user and the contractor's work force is given a low priority.

Training courses addressing the above is much needed, preferably arranged through the contractors own organisation, with the assistance of the DPWH. If improvements cannot be seen, this subject could be made a prequalification requirement.

CAPACITY OF URBAN ROADS USING AREAL DENSITY CONCEPT

by

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ABSTRACT

Capacity determination from speed-flow curve requires knowledge of passenger car units (PCU) for different types of vehicles in the traffic stream. PCU for a vehicle is a complex parameter and depends on all factors of geometry and traffic operation that will affect the behaviour of a vehicle in the traffic stream. Its exact determination considering the effect of all these factors is the real challenge to the traffic engineers. Further, the terms traffic density (veh/km) and flow (veh/hr) remain no longer valid for mixed traffic conditions prevailing in India and other developing countries. These parameters have been redefined in the present study to suit the mixed traffic situations. Data collected at four mid block sections of urban roads in New Delhi have been used to develop speed-areal density relationships. It has been established that the capacity of a road can be determined without using PCU values of individual vehicle types also. These sweeping concepts of a generalised formulation of traffic variables provides most realistic assessment of all traffic behaviour.

INTRODUCTION

Traffic on urban roads is of mixed nature in all countries. The term "mixed" however, is understood differently in different parts of the world. While a truck mixing with the passenger cars makes the traffic stream heterogeneous in Australia and other developed countries, it is still considered homogeneous in developing countries like India. The characteristics of a traffic stream change considerably with the number of vehicle categories present. In the analysis of traffic flow, the various types of vehicles in the stream are converted into a common measure which is considered to be an equivalency for the vehicle type. The most accepted such equivalency is the common unit of passenger car. Such a common unit for each type of vehicle is designed with due consideration of static and dynamic characteristics of vehicles. Thus, all vehicles of a heterogeneous traffic stream are converted to an homogeneous equivalent in passenger car unit (PCU). Traffic engineers normally employ prior PCU values in capacity analysis. Any bias in these values will naturally lead to bias in capacity estimation and the facility will be either over designed or under designed.

Various researchers in India and abroad have determined PCU values for given types of vehicle. The interesting point to note is that each of these studies has resulted in a different set of PCU values. This can be considered as the sufficient basis to suspect the validity of static PCU values, given in national standards, to all traffic and geometric situations. PCU by its definition is the amount of interaction caused by a vehicle type to the entire traffic stream. This interaction will change with all those factors that can affect the behaviour of a vehicle in the traffic stream. Exact determination of PCU incorporating the effect of all factors of geometry, traffic and control is a complex task. This research is aimed at estimation of capacity of urban roads serving mixed traffic without making use of PCU values of different categories of vehicles.

BACKGROUND

The basic parameters of a traffic stream are flow, density and speed. The interrelationships of these parameters are known as the traffic flow models. The speed-flow curve is normally used to determine the capacity of an urban road. A considerable amount of work has been done in developed countries to establish speed-density and speed-flow curves for urban streets. The analytical concepts developed for uniform traffic

have been extended to mixed traffic also, but it has not proven to be realistic as the behaviour of mixed traffic is entirely different from that of uniform traffic. Headway, for example, is the gap between two consecutive vehicles in a stream. Researchers have used this parameter extensively to determine the flow at intersections and urban roads. In the case of mixed traffic, measurement of headway for different combinations vehicle group is a complex task. The problem becomes manifold in absence of lane discipline when vehicles do not move one after the other but go abreast. Also, it is not logical to define an average headway for a traffic stream consisting of small sized vehicles with their projected static area as low as 1.14 m^2 and large sized vehicles with their static area as high as 23 m^2.

Capacity determination from the speed flow curve knowledge of passenger car units for different types of vehicles which is again a complex parameter. The speed-density relationship has also been of much interest to the researchers from very early days. Greenshield (1934) proposed a linear relationship between these two parameters as given in equation (1).

$$U(k) = U_{max}\left[1 - \frac{k}{k_j}\right] \quad (1)$$

where,

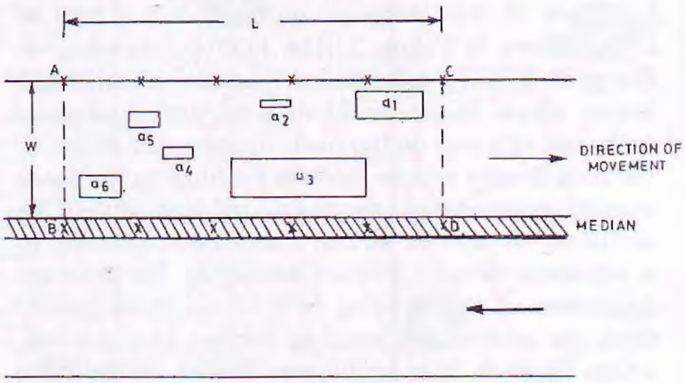
$U(k)$ = speed at density level k
U_{max} = maximum speed at zero density, and
k_j = jam density

Later, it was observed that the linear relationship between speed and density does not hold good for all ranges of density and other forms were suggested (Edie, 1961; HCM, 1985, Chari and Badrinath, 1983; Chandra et at, 1992). In the case of mixed traffic, the terms like density and flow lose their credence when expressed in their conventional forms. It is therefore, imperative to first redefine these terms to suit the mixed traffic conditions.

FLOW PARAMETERS FOR MIXED TRAFFIC

Density in its conventional form is defined as the number of vehicles in one kilometer length of road or lane. This definition lose its meaning in mixed traffic situation where wide variation exists in the physical sizes of the vehicles. One bus, for example, can replace 15 small sized vehicles like scooters or bicycles changing the density in vehicles per kilometer drastically. Density and flow in mixed traffic are very much controlled by the composition of the traffic stream. As a result, vehicles per kilometer will not give the feeling of congestion unless accompanied by the proportional composition of the traffic stream. Further, lane discipline is not very strictly imposed on road users in India. The vehicles do not move in file and overtaking is common due to large variation in speed and acceleration capability of the competing vehicles. Small sized vehicles like scooters move side by side in the same lane. In extreme situations, the lane occupied by a vehicle is more that one but less than two.

Due to these reasons a new concept of density is introduced in this paper. It takes into account the longitudinal and lateral spacing of vehicles. It is referred to as "areal density" in the subsequent discussion. Areal density is defined as the total projected rectangular area of vehicles over unit area of the pavement. In other words, it is the per cent area of the carriageway occupied by vehicles at a given instant of time. This is a non-dimensional parameter and its value ranges from 0 to 1. Figure 1 illustrates the proposed definition of areal density. To differentiate from the conventional form of traffic density, it has been denoted by A_d in this paper.



$$\text{AREAL DENSITY} = \frac{a_1 + a_2 + \dots + a_6}{L \times W}$$

$a_1, a_2 \dots a_6$ = PROJECTED AREAS OF VEHICLES (SQM)
L = LENGTH OF TRAP (m)
W = WIDTH OF PAVEMENT (m)
* = POSITION OF FLAG

Figure 1: Measurement of Areal Density

As for uniform traffic, flow is the product of density and speed. The same philosophy is used in this study also. The areal density flow is defined as the product of areal density and stream speed.

$$Q_d = A_d * V_m \quad (2)$$

where,

Q_d is the areal density flow,
A_d the areal density, and
V_m the mean stream speed.

The units of flow in equation (2) is that of speed but it differs in its physical sense. It represents the percentage of pavement area occupied by vehicles and this occupied area moving with some constant speed. Mean stream speed is calculated by equation (3).

$$V_m = \frac{\sum^{k} V_i * n_i}{\sum n_i} \quad (3)$$

where,

V_i is the speed of vehicle of category i,

n_i is the number of vehicles of category i, and

k is the total number of vehicle categories

DATA COLLECTION

Data for this study was collected by video filming the following midblock sections of urban roads in Delhi.

i) Section in Harinagar area

ii) Section in front of the JP Hospital

iii) Section in Shakarpur area on Vikas Marg

iv) Section on MG Road.

Locations of these sections are marked in a map of Delhi shown in Figure 2. The field experiment was designed to have information on areal density and stream speed. Measurement of areal density requires formation of a trap on the road. As the eventual use of the areal density is to be made in establishing the speed density relationship, the length of trap should be sufficient to provide stream speed corresponding to a particular density level. Considering the practical limitations of the focusing field of the video camera from the roof of the building located near the site, a trap of 25 to 35m length was formed on the road. Five flags, each of about 1.5m height, were erected on both sides of the road at regular interval as shown in Figure 1. The camera was focused to cover as much length of the road as possible and at least all the ten flags forming the trap. The data was recorded for about 90 minutes during peak period on a typical weekday. Table 1 provides the details of trap length and other geometric conditions observed at four sections selected for this study.

Table 1: Details of Sections

S1 No.	Section	Trap Length L (m)	Road Width W (m)
1	Hari Nagar	32	6.2
2	JP Hospital	27	16.0
3	Shakarpur	26	10.2
4	MG Road	33	10.5

DATA EXTRACTION

The recorded film was replayed on a large screen TV monitor in the laboratory. The reference points (flags) were transferred and the grid was formed on the screen. The film was paused at any instant of time and the vehicles enclosed by the trap were counted. To make the data amenable, vehicles having similar characteristics were grouped together and all vehicles were divided into 6 categories. The average physical dimensions of each of these categories and their projected rectangular area are given in Table 2.

Table 2: Vehicle Categories and Their Physical Dimensions

S1 No.	Vehicles Grouped	Category Name	Average Dimension Length (m)	Average Dimension Width (m)	Projected Rectangular Area (Sq m)
1	Car, Jeep, Taxi Van, Minibus	Car	4.60	1.70	7.82
2	Bus, Truck	Bus	9.35	2.46	23.00
3	3-Wheeler	3-Wheeler	2.75	1.40	3.85
4.	Scooter, Moped, Motor Cycle	2-Wheeler	1.90	0.76	1.44
5.	Pedal Cycle	Bicycle	1.90	0.60	1.14
6.	Pedal Rickshaw	Tricycle	2.75	0.75	2.06

Classified counts of vehicles within the trap area provided the areal density as explained in Figure 1. For the purpose of speed measurement, the film was rewound until the front wheels of vehicles of a particular category counted for areal density calculation were on the first end of the grid (line AB in Fig. 1). The time taken by the vehicle to clear the trap length was noted to the accuracy of 0.1 second. Similarly, speeds of other categories of vehicles within the trap length were also determined. Mean stream speed (V_m) was then calculated using equation (3).

SPEED – DENSITY RELATIONSHIP

Data on stream speed at different levels of areal density were obtained from the film as explained above. Areal density was plotted against the mean stream speed and several forms of mathematical relationships were tried for the best fit to the data. Table 3 gives these relationships as obtained for different sections along with their degree of fit. As may be seen, the logarithmic form of relationship gives the highest correlation for all the sections. Therefore, this form was adopted for further analysis. The final speed – areal density curves for the sections selected for this study are shown in Figures 3 to 6.

DETERMINATION OF CAPACITY

The speed-flow curve is normally used to calculate the capacity of a road. This curve can be generated from speed-density relationship using the equation;

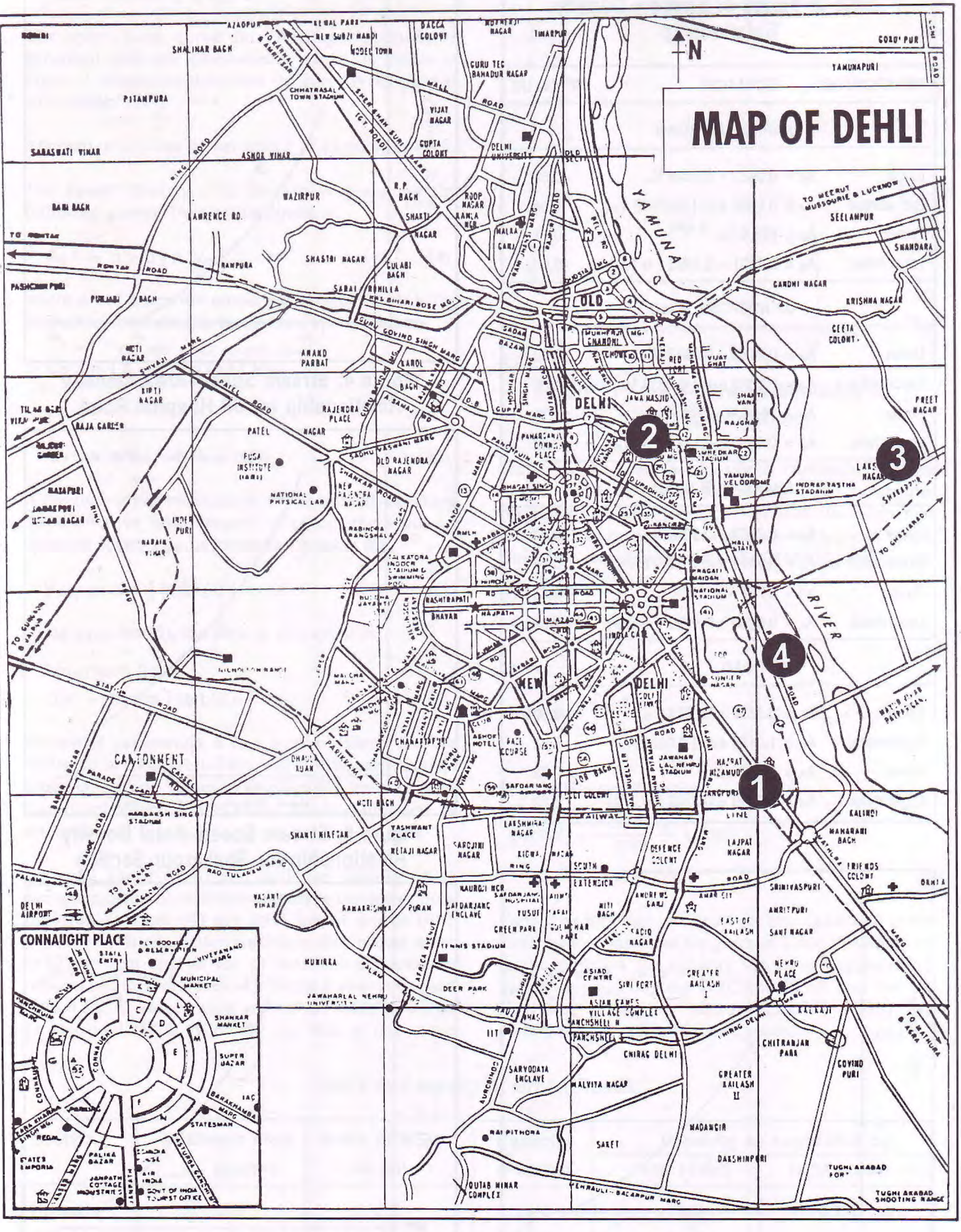


Figure 2: Locations of Sections Selected for Study

Table 3: Forms of Speed – Density Relationship

RELATIONSHIP	EQUATION	R^2 VALUE
	HARINAGAR ROAD	
Linear	$A_d = 0.2933 - 0.0044\ V_m$	0.61
Exponential	$A_d = 0.8886 \exp(-0.05672\ V_m)$	0.64
Power	$A_d = 675.5\ V_m^{-2.4365}$	0.61
Logarithmic	$A_d = 0.7401 - 0.1982\ ln\ (V_m)$	0.66
	JP HOSPITAL ROAD	
Linear	$A_d = 0.2173 - 0.0039\ V_m$	0.79
Exponential	$A_d = 0.5558 \exp(-0.0634\ V_m)$	0.80
Power	$A_d = 78.06\ V_m^{-2.0454}$	0.75
Logarithmic	$A_d = 0.5454 - 0.1331\ ln\ (V_m)$	0.82
	SHAKARPUR ROAD	
Linear	$A_d = 0.3163 - 0.0069\ V_m$	0.83
Exponential	$A_d = 0.9472 \exp(-0.0776\ V_m)$	0.76
Power	$A_d = 46.67\ V_m^{-1.8498}$	0.63
Logarithmic	$A_d = 0.6930 - 0.1733\ ln\ (V_m)$	0.88
	MG ROAD	
Linear	$A_d = 0.3135 - 0.0044\ V_m$	0.80
Exponential	$A_d = 1.0176 \exp(-0.05220V_m)$	0.84
Power	$A_d = 864.9\ V_m^{-2.4112}$	0.85
Logarithmic	$A_d = 0.8099 - 0.2102\ ln\ (V_m)$	0.89

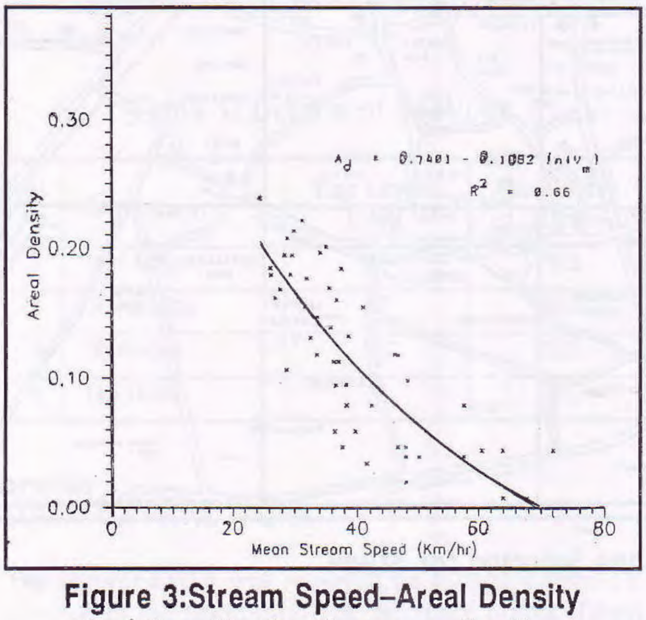


Figure 3: Stream Speed–Areal Density Relationship for Harinagar Section

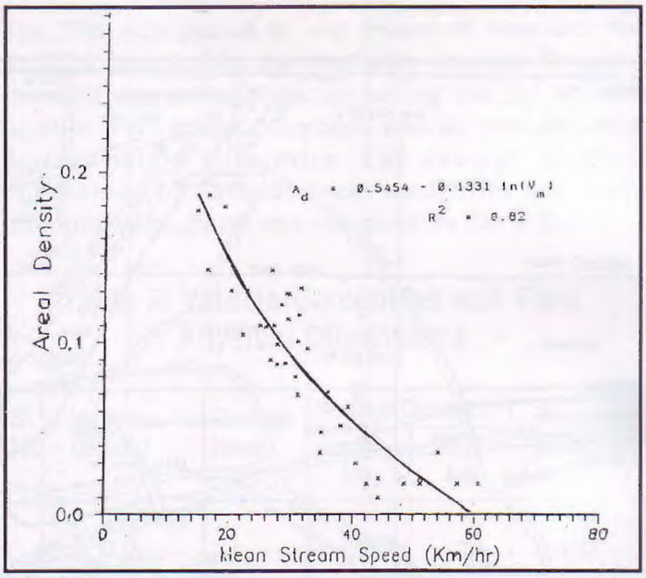


Figure 4: Stream Speed–Areal Density Relationship for JP Hospital Road

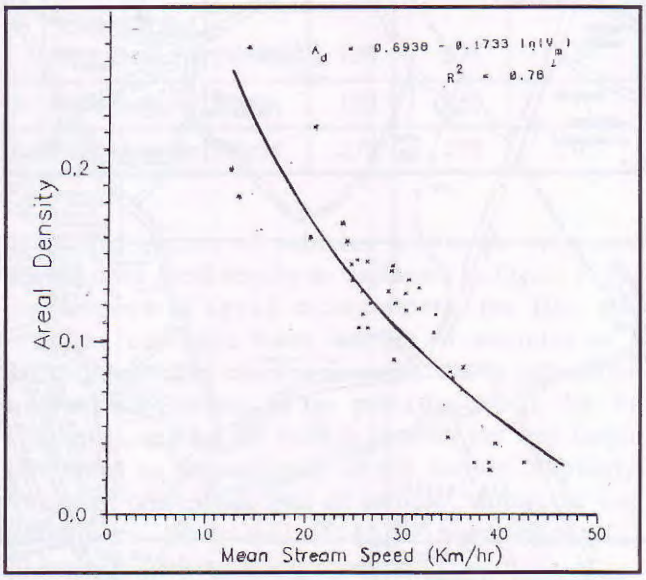


Figure 5: Stream Speed–Areal Density Relationship for Shakarpur Section

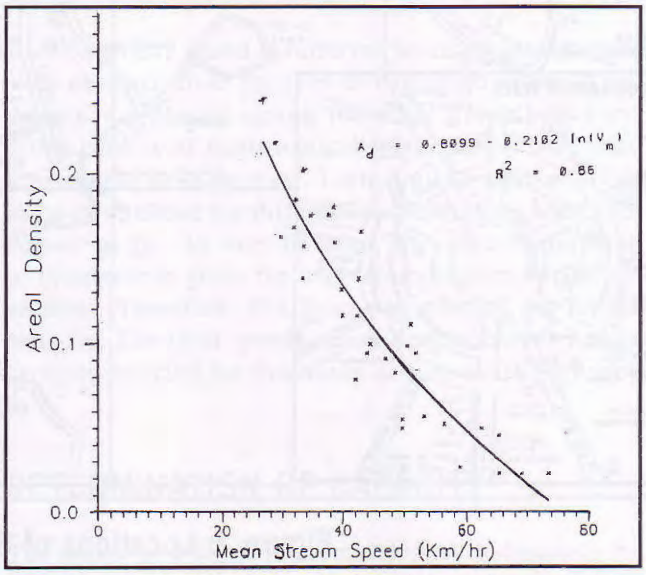


Figure 6: Stream Speed–Areal Density Relationship for MG Road

Flow = density x speed

The speed-flow curve for Harinagar section, as generated from the speed-density curve, is shown in Figure 7. Maximum flow from the curve is obtained as 3.05 km/hr.

Alternatively, it can be calculated as explained below.

The speed density relationship is given by the following general form of the equation.

$$A_d = a - b\,ln\,(V_m) \qquad (4)$$

where a and b are the model parameters. Flow is the product of areal density and stream speed. Hence,

$$Q_d = [\,a - b\,ln\,(V_m)\,]\,V_m$$

or

$$Q_d = a\,V_m - b\,V_m\,ln\,(V_m) \qquad (5)$$

If the flow given by equation (5) is maximised taking the derivative with respect to speed, the value of optimum speed V_{om}, is given by equation (6).

$$V_{om} = \exp\,[\,(a\text{-}b)\,/\,b\,] \qquad (6)$$

Using equation (5), the flow at this speed is

Maximum flow

$$Q_m = b\,\exp\,[\,(a\text{-}b)\,/\,b\,] \qquad (7)$$

Values of parameters a and b as obtained for the Harinagar section are 0.7401 and 0.1982 respectively. Substituting these values in equation (7), the maximum flow is calculated as 3.05 km/hr which is the same as obtained from Figure 7.

Optimum speed (V_{om}) and optimum density (A_{od}) during maximum flow at this section as computed from equation (6) and (4) are 15.4 km/hr and 0.1982 respectively. It means that maximum flow occurs when 19.82 per cent area of the pavement is occupied by vehicles and this total area of vehicles moves at a speed of 15.4 km/hr. Hence, total area of the vehicles within the trap of LxW is A_{od}xLxW and that in one metre

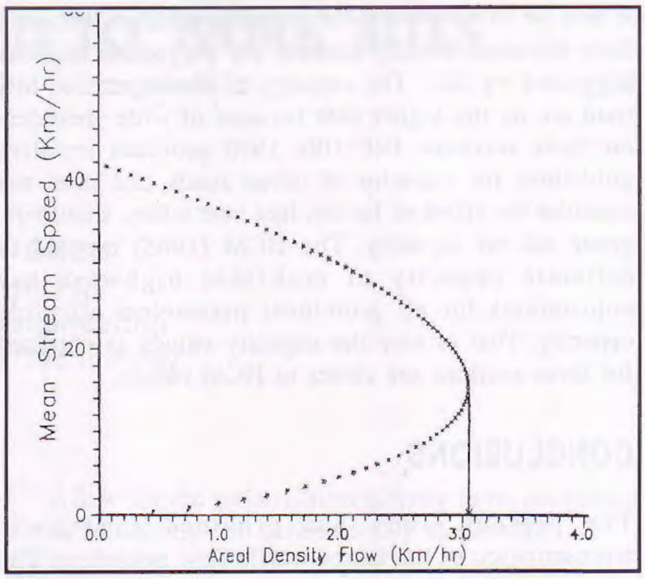


Figure 7: Speed–Flow Relationship for Harinagar Section

length of the road (as density is expressed per unit length of highway) is A_{od}xW. If A_c is the rectangular projected area of a passenger car then the number of cars that can be placed in this area is (A_{od} x W / A_c). Therefore, capacity in terms of PCU/hr is given by the following equation.

$$\text{Capacity} = \frac{A_{od} \times W \times V_{om}}{A_c} \times 1000$$

or

$$\text{Capacity} = \frac{Q_m \times W}{A_c} \times 1000\ \text{PCU/hr}\ \left[A_{od} \times V_{om} = Q_m\right] \qquad (8)$$

For the Harinagar section,

$$\text{Capacity} = \frac{3.05 \times 6.2}{7.82} \times 1000$$

$$= 2419\ \text{PCU/hr}$$

Capacities for other sections were also calculated in the same manner and these are given in Table 4. Also given in the table are the capacity values as suggested by Indian Roads Congress (IRC:106-1990) and the US Highway Capacity Manual (HCM, 1985) for corresponding widths of urban roads.

Table 4: Capacity of Urban Roads

Section	Maximum Flow Q_m (km/hr)	Width of Road W (m)	Capacity (PCU/hr)	Capacity as suggested by IRC (1990)	HCM (1985)
Harinagar	3.05	6.2	2419	2303	2958
JP Hospital	2.95	16.0	6036	5943	6327
Shakarpur	3.49	10.2	4552	3788	4566
MG Road	3.64	10.5	4887	3900	5400

It may be observed that the capacity values as obtained from the areal density concept are very close to those suggested by IRC. The capacity of Shakarpur and MG road are on the higher side because of wide shoulders on these sections. IRC:106, 1990 provides tentative guidelines for capacity of urban roads and does not consider the effect of factors like lane width, shoulders, grade etc on capacity. The HCM (1985) method to estimate capacity of multilane highways has adjustments for all prominent parameters affecting capacity. That is why the capacity values as obtained for these sections are closer to HCM values.

CONCLUSIONS

The present study has provided a realistic representation of the mixed traffic flow behaviour. The concepts of areal density and areal flow have been successfully used to estimate capacity of urban roads. These sweeping concepts do not consider the lane width of 3.5m as the standard width required for a vehicle. Rather the total approach is considered which is more general. The advantage of this concept is that it does not require PCU values for different types of vehicles for capacity estimation. PCU is a complex parameter and its exact value is still not very well known. The flow maximisation technique used in this study considers all geometric and compositional effects on capacity.

Although the results of this study are applicable to traffic conditions prevailing in India, the concept of areal density and areal flow presented here can be applied to other conditions as well. As pointed out earlier, traffic in all countries is of mixed nature. The only difference is the diversity of vehicles in the mix. Traffic analysis in conventional method requires PCU values for each type of vehicle in the mix, whereas, the methodology presented in this paper gives capacity value in PCU/hr without using PCU for individual vehicle type.

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ROAD SAFETY RELATED TO WORK SITES

by

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INTRODUCTION

Southeastern Asian countries combine 2.2 billion population, account for 41% of global commerce and become the fastest growing region in the world. To meet the rapidly growing economic, many new infrastructure construction sites are under way. Efforts have been also devoted to the maintenance and reconstruction of existing facilities. The number of construction and maintenance activities of the highway network in the Asian region is increasing.

Highway construction activity is often conducted in a work site adjacent to moving traffic where the situation is often confusing to the motorist. This greatly increases the risk of injury both to the travelling public and to the construction workers. According to the conference on Asian road safety held in 1993, the accident rate on roadways have reached an alarming number. [1] The United States face a similar situation in which the number of fatalities that occurred in highway work sites increased from 489 in 1982 to 780 in 1988. [2]

Effective work site planning, design, and operation have become key elements in a safe and efficient transportation system. Proper work-site installation will increase the safety around the work-site.

TYPES OF WORK SITES

A work site is defined as a location where construction, maintenance, or utility operations are being performed or where previous operations have not yet been completed and potential hazards or traffic obstructions are still present. Equipment and material shall also be considered a part of the work site. [3] The three following functions of work sites should be met:

* Provide the maximum degree of safety by protecting both the public and the work force;
* Permit the maximum movement of the traffic through the work site with the minimum amount of public inconvenience;
* Allow for the construction activity to be conducted as efficiently and economically as possible.

Because the duration of the work to be performed influences the design of the traffic control site, it is important to define and identify the work site based on various measures of duration:

* **Long-Term Work Site.** Long-term activities are those during which the traffic control site is in place for several days or longer.
* **Intermediate-Term Work Site.** Intermediate-term activities require one to several days to perform; nighttime closures are often involved.
* **Short-Term Work Site.** Short-term activities are generally considered to be those in which it takes longer to set up and remove the traffic control site than it does to perform the work. Typically, the operation can be accomplished in 15 minutes or less.

PLANNING OF WORK SITES

Successful work site traffic control is dependent upon a well-conceived plan. Before a work plan is undertaken, several basic considerations for the work site should be identified. Three categories of data are needed: construction data, roadway data, and traffic data.

* **Construction Data.** The location of construction activities determines the degree of interference with normal traffic operations. The construction site is usually located on one of following positions: off-roadway, on-sidewalk, on-shoulder, or on-roadway. The magnitude of work area should include the number of lanes required and the length of work area. When activities are conducted on the roadway, the amount of roadway available for travel will be reduces.
* **Roadway Data.** The roadway data include cross-section dimensions, number and width of lanes, width of shoulders, clearance to roadside

obstacles, median width, and horizontal and vertical alignment.

* **Traffic Data.** The expected traffic volume on the roadway will affect the ability to use various traffic controls in work sites. The following data should be collected: average daily traffic, peak-hour traffic, traffic operation speeds, and the vehicular classification of the traffic flow.

Work Site Scheduling

Once the construction, roadway, and traffic data have been acquired, the appropriate type of work site can be determined. It is then important to establish the method to separate the traffic and work site activities. These activities can be separated in either space or time or both. Separation in space is accomplished by lane closure, detour, or temporary bypass. Separation in time is achieved by restricting the time that either traffic or construction activity can occupy a specific section of roadway. Whenever possible, work activity on major streets and highways should be restricted to off-peak hours to minimise conflicts with traffic. [4,5]

The difficulties associated with the completion of work on lanes carrying high volumes of traffic have made it necessary in some instances to schedule construction and/or maintenance operations at night. However, the problems related to work site delineation and warning device placement at night are increased. [6]

Speed Control Plan

The next step in work site planning is the formulation of the speed control strategy. Two general philosophies of speed control through construction sites exist:

(1) speed in the work site is similar to the speed on the highway before the start of the construction site, and

(2) the speed of traffic should be reduced in the work site.

To maintain the pre-construction operating speed through the construction site, all of the geometric design elements and traffic control devices should be maintained for safe movement at that operating speed. If it is desirable to reduce traffic speeds in the construction site, an effective method of speed reduction must be incorporated into the construction site design. Some commonly used methods are advisory speed limits, regulatory speed limits, signal control and flagging. [4,7]

Traffic Control Plan (TCP)

A traffic control plan (TCP) may range in scope from a very detailed document designed solely for a specific project to a simple reference such as standard plans, or a highway agency manual. [6] The degree of detail addressed in the TCP depends on the project complexity, traffic capacity requirements, and the extent of traffic interference with the construction activity.

A TCP should consist of detailed plan sheets or drawings showing the actual site conditions and traffic control requirements for the specific project. The plan of a traffic control site for a work site involves the selection and location of all temporary traffic control devices. Traffic control devices, such as signs, signals, channelization devices, pavement markings, barriers, and lighting devices are needed in construction sites to alert drivers to the impending conditions, warn them of hazards, and direct them along the proper path. Advance use of public information media can provide invaluable assistance to maintaining efficient traffic control and can be incorporated into the traffic control plan. Radio, television and newspaper can be effectively utilized to inform the public of anticipated delays or congestion due to construction activities. [6]

Appropriate crew sizes, materials, and equipment must be selected to meet the needs of the selected type of work site. The use of available equipment and personnel should be optimized for cost-effectiveness.

DESIGN OF WORK SITES

The goal in the design of effective traffic control through work sites is to provide driving conditions that resemble, as closely as possible, the highway conditions under normal operation. Such a goal should help to prevent accidents within the work site area. The traffic control site for a work area usually includes an advanced warning area, a transition area, an activity area, and a termination area. Figure 1 shows the traffic control site components.

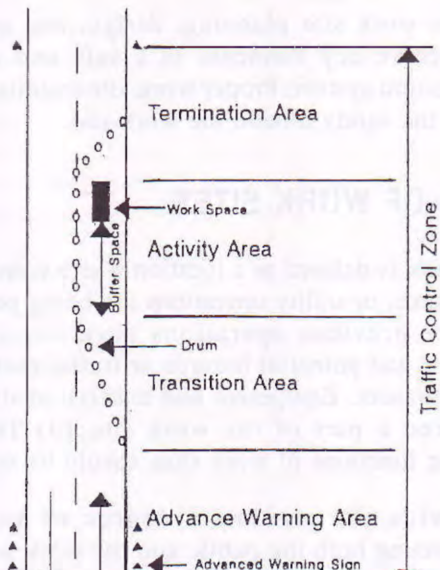

Figure 1: Design of a Work Site

Advance Warning Area

All traffic control sites should have an advance warning area. The advance warning area is important to alert drivers to potentially unusual or hazardous conditions so that driving speeds and driving practices can be adjusted in preparation for such conditions. The main traffic control devices used in the advance warning area are the diamond-shaped warning signs in the black-on-orange series specified for construction and maintenance operations.

The advance warning area starts at the beginning of the traffic control site and extends to the transition area. The driver is given information about the hazards ahead and the sections needed to travel safely through the area beyond. As soon as a channelizing device is encountered or a change in the normal travel path is imposed, the motorist has entered the transition area. [8,9]

Transition Area

A transition area is required when lanes are to be closed, travel path shifted, or both, to accommodate the work space. It is the portion of the traffic control site that commences at the downstream end of the advance warning area and extends to the beginning of the activity area. [6]

To provide a smooth, effective transition for motorists, it is important to provide for adequate transition taper length, sufficient pavement markings, and adequate channelization.

Activity Area

The activity area is where the maintenance or construction work is taking place, including space for equipment and materials. The activity area is the portion of the traffic control site that commences at the downstream end of the transition area and extends to the beginning of the termination area. The activity area consists of buffer space and work space. [8,9]

Buffer space is an optional element in the activity area that provides a recovery space for errant vehicles and separates traffic flow from the work activity. Work activity should not occur and equipment and materials should not be stored within the buffer area. [8,9]

The work space is that portion of the activity area set apart for the actual maintenance or construction work, equipment, and material storage. The work space area needs to be delineated to exclude vehicular and pedestrian traffic. [8]

Termination Area

The termination area is used at work sites to allow traffic to clear the activity area and return to normal traffic operations. It is the final portion of the traffic control site that extends from the downstream end of the activity area to the END CONSTRUCTION or END ROAD WORK sign. If lane closures or transitions are utilised, downstream lane tapers will be required and should adhere to the same principles as discussed in the transition area.

Layouts

Since it is not practical to prescribe detailed standard layouts for all the situations that may arise, minimum standards are presented here. Additional protection should be provided when special considerations and hazards exist. The protection needed for each situation should be based on the speed and volume of traffic, duration of operation, and exposure to hazards.

OPERATION OF WORK SITES

In order to provide the maximum degree of safety and traffic flow in work sites, guidelines have been provided to aid the installation and removal of traffic devices.

Premarking

Premarking can facilitate the placement and maintenance of traffic control devices in work sites. The pavement can be marked to show sign locations, taper configurations, and barricade positions. Spotting the pavement with white paint will also help in situations where channelizing devices are to be removed at the end of each day and replaced in the same position the next day, or where realignment is necessary due to being struck by a vehicle or blown over by the wind. [10]

Proper Sequence

When preparing to set up a work site, the first step is to have a designated and dependable traffic control vehicle. Ensure that the truck is in good condition. Prepare the truck by loading in the reverse order of unloading, placing items that are needed first toward the back of the truck. Make certain that all necessary tools and equipment are on the truck, then secure the load and head for the work site. A truck may also be used in the work sites to deter motorists from entering the work site and to protect workers from oncoming traffic.

The following is a suggested guideline on the proper sequence for installation and removal of traffic control devices:

1. The first control device set should be the leading warning device. All required advance warning signs should be installed first to provide downstream protection. The work site installation then proceeds with the
   - *Advance warning area

- Transition area
- Activity area
- Termination area

If work site signing is necessary for both directions of travel, sign installation should begin with the sign furthest from the work area followed by the signs on the same side as the work site. Sign installation should proceed down the roadway toward the work area.

2. If flagging is necessary, start flagging after advance signs are erected. If no flagging is used, the installation of channelization devices can begin after the placement of the advance warning signs.

3. If available, a vehicle may be placed between approaching traffic and the workers installing channelizing around the work area. The vehicle may be removed after the installation of all channelizing devices.

4. After all work is completed, the work site traffic control devices should be removed in the exact opposite sequence that they were placed. Starting in the termination area, devices are removed, working upstream, against traffic, but always remaining within the closed lane. Pick up the advanced warning signs last. [10]

During the installation procedures, attention should be given to the following issues:

* **Placement.** Placement should be done so that signs will effectively convey their message to drivers. Signs should command the respect of drivers and give them enough time for proper response. It is essential for safety that work site signs mean the same thing in every state, city, and town. Use only approved signs, and use them correctly.

  Work site signs should not be obstructed or obstruct other signs. In order to improve their visibility, work site signs should generally be located in advance of horizontal and vertical curves rather than after such curves. [6]

* **Channelization Devices.** Channelization devices should provide a smooth and gradual transition so that drivers can safely pass the work site. Devices should be spaced in such a manner that makes it apparent that an area is closed to traffic. This is dependent on the type of activity, speed limit, and geometric alignment of the facility, but a general guideline for the maximum spacing between devices is equal to the posted speed limit. For example, if the speed limit on a roadway is 90 km/hr, the devices should be placed at a maximum spacing of 15 meters. It is important to remember that all channelization devices be spaced the same distance from one another. [6]

* Ballasting. When signs or channelization devices are used, it is necessary to use ballast to ensure they will not blow over or be easily displaced. Ballasting of devices can be done by placing sand bags on the lower portions of frames. Blocks, bricks, or large rocks should not be used as ballast. [6]

CONCLUSIONS

Work site safety has become a major concern as awareness of risk to workers, pedestrians, bicyclists, and vehicle occupants has grown. This paper describes the procedures which identify the characteristics of work sites and develop traffic control guidelines for these works zones. Understanding and following the guidelines should help to enhance the traffic flow and road safety in work sites.

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REPORT ON THE PRIORITY NEEDS OF ROAD DEVELOPMENT IN ASIAN COUNTRIES

by

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This report was presented at the PIARC Committee 3 Meeting (Working Group 1) from 20-22 November 1994 in New Delhi, India under the broad title of a regional report on Asian Countries. It was felt that this report will be interesting to members of REAAA. It has been modified slightly.

ECONOMIC CONDITIONS OF VARIOUS ASIAN COUNTRIES

There are various countries and territories in the Asian Region, as shown in Table 1; ranging from the lowest income countries with GNPs per capita of only about $200 such as Myanmar, Cambodia, Vietnam, Laos, Nepal and Bangladesh; low income countries such as India ($330 per capita), China ($370 per capita), Pakistan ($400 per capita), and Sri Lanka ($500 per capita); medium income ASEAN countries such as Indonesia ($610 per capita), Philippines ($740 per capita), Thailand ($1,580 per capita) and Malaysia ($2,490 per capita); to countries and territories called "NIES" which have developed rapidly, such as Korea ($6,340 per capita), Taiwan ($8,000 per capita), Singapore ($12,890 per capita), and Hong Kong ($13,200 per capita). As briefly described, the Asian Region consists of countries of various stage of economic development.

Countries in this region are generally blessed with rich natural resources and have economic structures to acquire foreign currency through the export of primary products, to import capital goods and intermediate goods by the acquired foreign currency, and to reexport products manufactured from imported goods. Among various countries, NIES countries and territories are introducing the economic structure of heavy chemical industry and/or high-tech industry.

The lowest income countries with per capita GNPs of approximately $200, are represented by Myanmar and Cambodia with inconstant political backgrounds, by Vietnam and Laos with planned economies base on socialism that have started to move to market economies, and by Nepal and Bangladesh that often suffer serious damage from natural disasters. The 1991 economic growth rate of these countries ranged from 2.0 to 5.6% to the previous year, but the inflation rate was extremely high from 8.2 to 67.6% because the countries had large trade deficits and unstable economies.

For the low income countries with per capita GNPs from $300 to $500; except for Sri Lanka whose gross national product is high, but on a per capita basis is very low because the total population is quite large. This is similar for China with 1,150 million persons; India with 865 million persons and Pakistan with 116 million persons. The 1991 economic growth rate for these countries is comparatively high; from 4.8 to 7.3%, except for India with 2.5%. The inflation rate is comparatively high; from 11.8 to 13.9%, except for China with 2.9%. These countries all have a deficit trade balance except for China. In China, prices are significantly stable, the trade balance is favourable and the economy is rapidly growing. In the coastal areas of Kwangtung Province in particular, there are close and active trade and investment relationships with the adjacent countries and territories of Taiwan and Hong Kong. This South China Economic Zone has achieved rapid economic growth.

The medium income ASEAN countries have achieved rapid economic growth with active introduction of foreign currency and export encouragement economies that have contributed greatly to the growth of internal economies and political stabilization. These countries are attracting world attention as areas of rapid economic growth. The 1991 economic growth rate of ASEAN countries is very high, from 6.6 to 8.8%, except a minus 0.9% of Philippines, of which economy is still influenced by political disorder of the previous decade but is emerging from the worst of times. The inflation rate is comparatively stable, within the range from 4.4 to 9.4%, except for the Philippines, which has a rate of 17.7%. Trade balances are deficits, except for Indonesia, which has oil and natural gas resources.

TABLE 1: Economic Conditions of Asian Countries (1991)

Country or Territory	Population (10^5)	GNP (US$ 10^5)	GNP/capita (US$ 1)	Increase of GDP (%)	Inflation Rate (%)	Trade Balance (US$$10^5$)
Cambodia	8.7	1,725	200	n.a.	n.a.	n.a.
Sri Lanka	17.2	8,665	500	4.8	12.2	Δ 10.2
Hong Kong	5.9	77,302	13,200	4.2	12.0	Δ 16.8
India	865.0	284,688	330	2.5	13.9	Δ 27.8
Pakistan	115.6	46,725	400	6.5	11.8	Δ 29.1
Thailand	56.7	89,548	1,580	8.2	5.6	Δ 97.1
Nepal	19.1	3,289	180	2.0	8.2	n.a.
Laos	4.3	965	230	n.a.	n.a.	n.a.
Malaysia	18.3	45,787	2,490	8.6	4.4	Δ 23.4
Bangladesh	108.8	23,449	220	3.6	8.9	Δ 18.0
China	1,150.1	424,012	370	7.3	2.9	81.2
Korea	43.2	274,454	6,340	8.4	9.7	Δ 96.6
Singapore	3.0	39,249	12,890	6.7	3.4	Δ 71.3
Philippines	62.7	46,138	740	Δ 0.9	17.7	Δ 32.0
Indonesia	181.4	111,409	610	6.6	9.4	32.7
Vietnam	67.8	5,016	200	3.8	67.6	Δ 4.0
Taiwan	20.2	161,539	8,000	7.2	3.6	133.2
Myanmar	42.5	n.a.	200	5.6	34.0	Δ 5.7
Japan	124.0	3,337,191	26,920	4.0	3.3	1,031.0
USA	250.9	5,445,825	21,810	Δ 1.2	4.3	Δ 736.0
UK	57.5	923,959	16,080	Δ 2.2	5.9	Δ 180.0
France	56.5	1,099,750	19,590	1.2	3.1	Δ 101.0
Germany	77.3	1,411,346	22,360	3.6	4.5	231.0

Notes: *GNP and GNP/capita of Germany shows those of the former West Germany only.*
Data of Nepal is based on that of 1990
Population, GNP and GNP/capita of Taiwan are based on those of 1990
GNP/capita of Myanmar is based on that of 1986
Resource: *Statistics of UN and the World Bank*

NIES countries and territories have developed significantly throughout the world. The per capita GNP is very high and their 1991 economic growth rates are high ranging from 4.2 to 8.2%, and the inflation rate is stable, ranging from 3.4 to 12.0%. These countries have deficit trade balances, except for Taiwan.

CURRENT STATE AND PROBLEMS OF ROADS IN ASIAN COUNTRIES

It can be concluded that road coverage conditions in Asian countries (see Table 2) have a close relationship with the economic conditions of each country. Hong Kong and Singapore have highly improved roads with the Pavement Ratio of over 90%. These two countries have been highly developed. Conversely, the Total Length of Road per Area are very low in Myanmar, Laos and Nepal. The pavement ratio is below 10% in Laos and Bangladesh.

When discussions are held on the road problems of Asian countries such problems could be classified into the four groups, depending on the economic

TABLE 2: Road Coverage Conditions in Asia Countries

Country	Total Length of Roads (km)	Total Length of Paved Road (km)	Total Length of Road per Capita (m/capita)	Total Length of Road per Area (m/km)	Pavement Ratio (%)	Surveyed Year
Sri Lanka	24,752	19,732	1.63	377	79.7	1982
Hong Kong	1,244	1,244	0.24	1,185	100.0	1983
India	1,357,784	709,527	1.91	413	52.3	1982
Pakistan	94,987	64,600	1.09	119	68.0	1983
Thailand	159,618	30,093	3.29	311	18.9	1983
Nepal	5,546	2,484	0.36	39	44.8	1983
Laos	7,395	622	2.27	31	8.4	1974
Malaysia	30,412	24,223	2.76	92	79.6	1983
Bangladesh	161,359	15,315	1.75	1,121	9.5	1984
China	915,079	705,670	0.90	90	77.1	1983
Korea	54,599	21,279	1.39	553	39.0	1983
Singapore	2,568	2,369	1.04	4,382	92.3	1983
Philippines	155,798	19,943	3.07	519	12.8	1983
Indonesia	182,882	116,357	1.20	96	63.6	1983
Nyanmar	22,471	8,206	0.70	33	36.5	1978
Japan	1,123,283	598,766	9.46	2,974	53.3	1983

Resource: Trends in the Development of Roads and Transport (No.2) UN-ESCAP 1987

condition of each country. The reason for this is because problems vary according to the economic and social development of each country.

The lowest income countries such as Laos, Bangladesh, Myanmar, Vietnam, Cambodia and Nepal should be classified into the first group. In these countries, motorization is not yet fully developed, and it is necessary to improve the road networks if rapid economic growth is to be expected in the future. The main problems in these countries are:–

* securing the necessary funds for road improvement;
* improvement of the arterial road networks throughout the country including rehabilitation of existing sections;
* construction of large structures such as bridges; and
* the shortage of engineers, technicians and necessary machinery for road construction.

The low income countries such as China, India, Pakistan and Sri Lanka which rely on a relatively developed railway network for transportation can be classified into the second group. Motorisation has only started to develop in recent years and is expected to continue to develop steadily in the future. Maintenance of the existing roads and also upgrading and expansion of the road networks are recognised as urgent needs to meet the rapid economic and social development of the these countries. Construction of inter-urban expressways has started and some sections are already opened to traffic in these countries. In addition to the problems faced by countries in the first group, the acquisition and dissemination of the wide range of road technologies for planning, survey, design, construction and maintenance and to study and implement various options of road financing systems to secure funds are additional problems that the countries in the second group must face.

Thailand, Malaysia, Indonesia, Philippines of the ASEAN countries can be classified into the third group. Motorization has developed in these countries, and it is presumed that it will continue to grow in the future.

Heavy traffic congestion is occurring in urban areas of these countries. It is necessary not only to maintain the existing roads, but also to construct new roads and facilities including metropolitan expressways, mass transportation media in urban areas, and high-standard highways for local areas. These countries are now facing the challenges related to the second phase of road development, one of which is the securing of funds for these objectives. A part of the cost of road improvements is obtained from the toll road systems or private funds, and other measures are being studied. Moreover the general public consensus is strong objections for the establishment of road fees for the installation of toll roads, governmental guarantees for incomes of the private companies which provided the roads and official guarantees for companies bonds to raise funds.

Finally, NIES countries and territories, such as Singapore, Hong Kong, Taiwan, and Korea can be classified into the fourth group. The infrastructure is fully established in these countries, and high standard roads have been provided. Expressways are also actively being developed and these countries and territories face traffic congestion and traffic safety problems, in addition to issues of the environment such as are faced by the industrialized countries. Because of their economic growth, the fourth group can also suffer from traffic noise and air pollution caused by exhaust gases, and comprehensive traffic control system and traffic demand management are studied or being installed in these countries.

Therefore priority needs for road development in Asian countries should be surveyed and carefully classified according to the groups of countries mentioned above.